

1 Normal Galaxies

- a) Our sun is ~ 10 kpc from the center of the Galaxy. How far from the center would it appear to be, in *arcminutes*, if an observer were to look at our Galaxy from a distance of 10 Mpc?
- b) If v is the mean velocity of a random velocity distribution of stars in three dimensions show that the measured mean velocity, V , in one dimension is:

$$V = v/\sqrt{3} \quad (1)$$

- c) Show that the circular velocity of matter in orbit around a central mass M at a radius R is, in units of 1000 km/s,

$$\left(\frac{v}{1000 \text{ km s}^{-1}} \right) = 2.08 \times 10^{-3} \left(\frac{M}{M_{\odot}} \right)^{\frac{1}{2}} \left(\frac{1 \text{ Kpc}}{R} \right)^{\frac{1}{2}} \quad (2)$$

- d) A galaxy has a mass of 3×10^{44} g, measured dynamically inside a radius of 30 kpc. If the ratio of visible to dark matter is 0.1, estimate the number of stars. What is the average density of the visible matter? Compare this with the critical density of the Universe, $\rho_c \sim 8 \times 10^{-30} \text{ g cm}^{-3}$.

2 Active Galactic Nuclei –I

Your answers to this question should be very brief.

The figure below shows the *observed* Spectral Energy Distribution (SED) of the nearby Seyfert 1 galaxy MCG $-6-30-15$. The dotted line shows the estimated *true* continuum. The following luminosities have been estimated:

Energy/Frequency Range	Luminosity (erg s^{-1})
Mid- to Far-infrared	4×10^{43}
Near-infrared/optical/UV	2×10^{43}
X-ray/ γ -ray	2×10^{43}

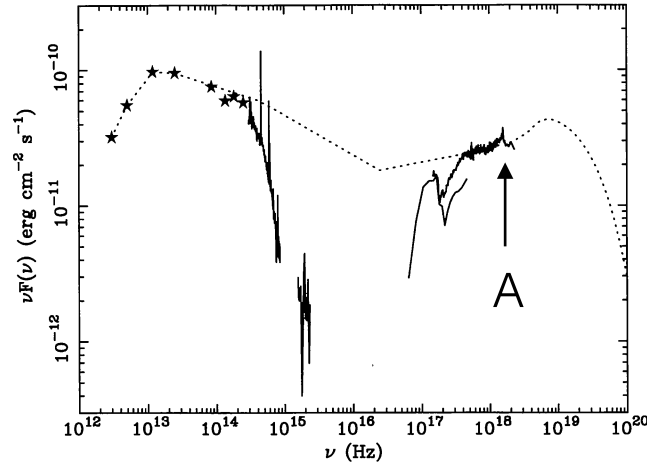


Figure 1: Spectral Energy Distribution (SED) of the nearby Seyfert 1 galaxy MCG -6-30-15.

- a) Estimate the bolometric luminosity.
- b) Why is there a large gap in the data centered at $\sim 10^{16}$ Hz?
- c) Roughly what frequency or energy range is important for photoionization? NOTE: Energy in keV = $0.0136 \times (\text{frequency in Hz} / 3.3 \times 10^{16} \text{ Hz})$.
- d) Roughly what frequency or energy range is important for Compton-heating?
- e) Why is the X-ray spectrum much more variable than that at lower energies (e.g. optical, infrared)?
- f) What is the feature labelled 'A'?
- g) Do you think the extrapolation of the spectrum beyond 10^{19} Hz is reasonable? Explain.
- h) If all the bolometric luminosity estimated in (i) is due to accretion, estimate a lower limit to the mass of the central black hole if it assumed that the source accretes below the Eddington limit, which is $L_{\text{EDD}} = 1.263 \times 10^{38} (M/M_{\odot})$.